

# Current Status of $K^+ \rightarrow \pi^0 \mu^+ \nu_\mu \gamma$ study

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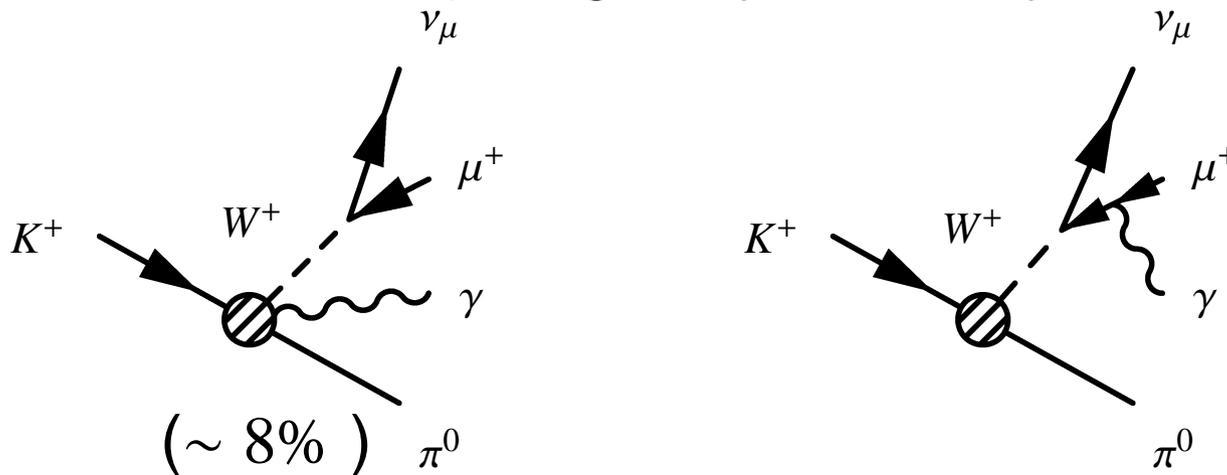
- ★ Introduction
- ★ Current Status of Data analysis: upgrade points.
  - Kp2g background estimation
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# Physics Motivations

## Chiral Perturbation Theory

QCD effective theory in low energy region  
quark field  $\rightarrow$  pseudoscalar meson field

(using Only Chiral Symmetry)



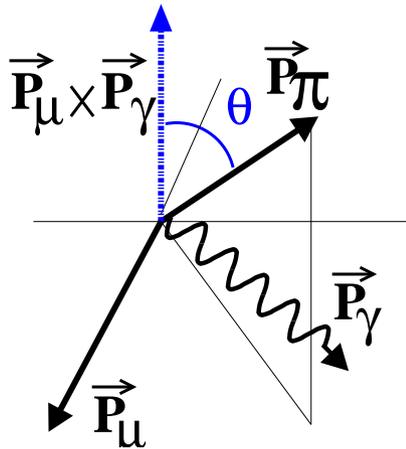
Structure Dependent

Internal Bremsstrahlung

Branching ratio is predicted as  $\sim 2.0 \times 10^{-5}$   
( $E_\gamma > 30\text{MeV}, \theta_{\mu\gamma} > 20^\circ$ )

# T-violation

$$\underline{\vec{P}_\pi \cdot (\vec{P}_\mu \times \vec{P}_\gamma)}$$



$N_+ \equiv$  Number of  $\theta < \pi/2$

$N_- \equiv$  Number of  $\theta > \pi/2$

$$A_\xi = \frac{N_+ - N_-}{N_+ + N_-}$$

(  $\pi$  up-down asymmetry against the “ $\mu - \gamma$  plane” )

within SM, this  $A_\xi = 1.14 \times 10^{-4}$  due to final state interaction.  
Good probe to the physics beyond SM(hep-ph/0305067)

# Experimental Status

Previous exp. @ Argonne National Laboratory (PR D8 1307(1973))

No events were observed. :

$$BR < 6.1 \times 10^{-5} (CL = 90\%)$$

**No observation yet!**

Other  $K_{l3\gamma}$  decays are already measured...

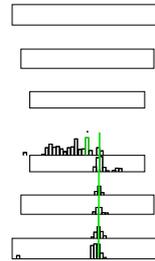
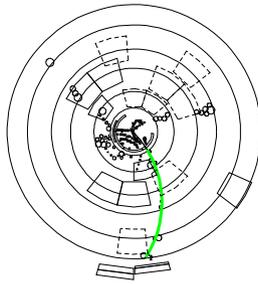
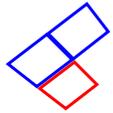
- ★  $K_{e3\gamma}^+$  ...  $(2.62 \pm 0.20) \times 10^{-4}$
- ★  $K_{e3\gamma}^0$  ...  $(3.62^{+0.26}_{-0.21}) \times 10^{-3}$
- ★  $K_{\mu3\gamma}^0$  ...  $(5.7^{+0.6}_{-0.7}) \times 10^{-4}$

**Structure Dependent Term: NOT MEASURED!**

# Event Display

3Gamma

SCALE 1:16.0

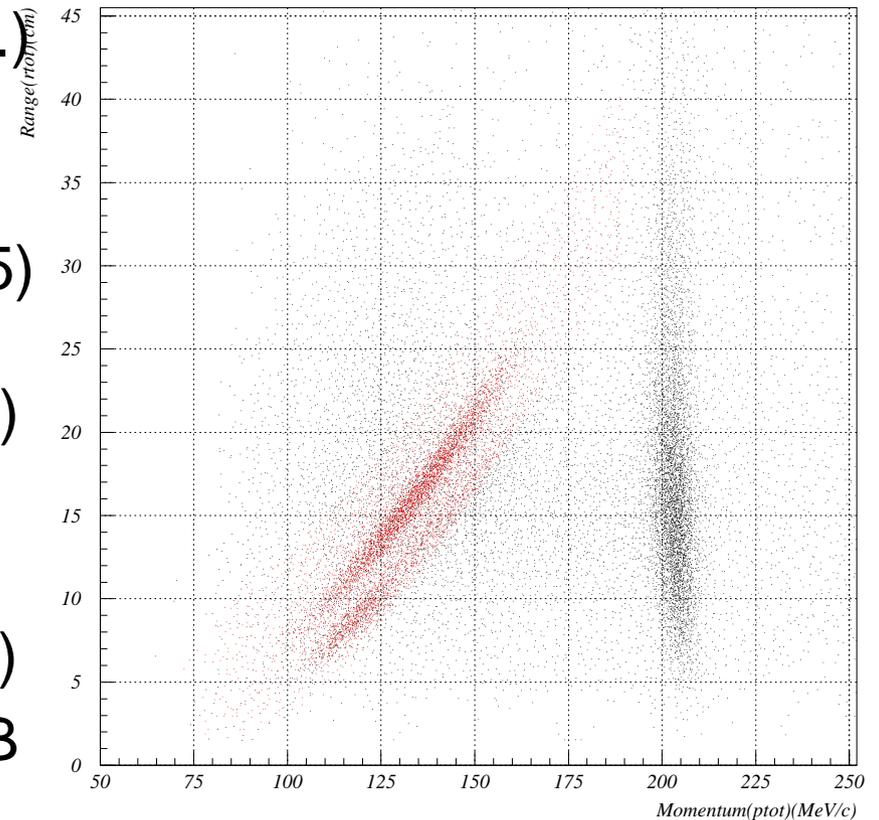


RUN 39415  
EVENT 426

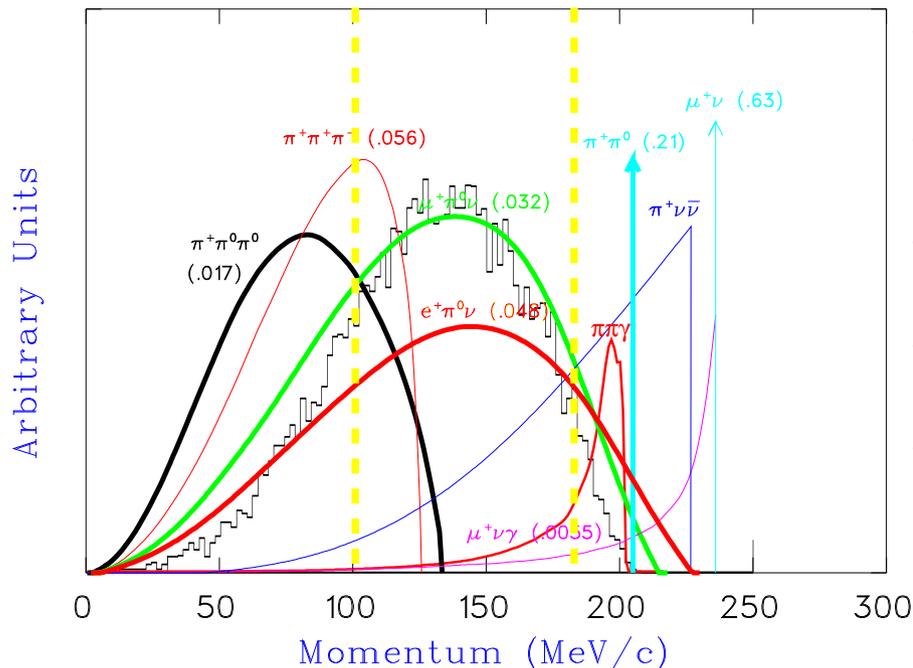
- ★ 3 $\gamma$  clusters in Barrel Veto
- ★ Right Stopping Counter
- ★ No Extra Activity

# G3PASS1/G3PASS2

- ★ PASS1 (common to  $K_{\mu 3\gamma}/K_{\pi 2\gamma}$  ana.)
  - Data Set: DLT \* 35
  - Number of KB\_LIVE:  $1.86 \times 10^{12}$   
(1.4 times larger than that of '95)
  - Data Reduction:  
1TB  $\rightarrow$  346GB(33.8%)(DLT\*13)
- ★ PASS2 (for  $K_{\mu 3\gamma}$ )  
(not so tight for Background study)
  - Data Reduction: 346GB  $\rightarrow$  60GB



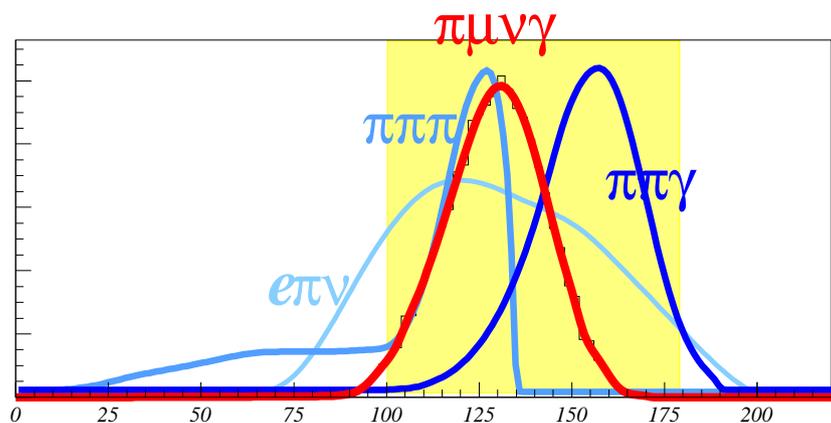
# Backgrounds Sources



- ★  $\pi^0 \mu^+ \nu_\mu$  +accidental/splitted  $\gamma$
- ★  $\pi^0 e^+ \nu_e$  +accidental/splitted  $\gamma$
- ★  $\pi^+ \pi^0 \pi^0$  +missing/overlapping  $\gamma$
- ★  $\pi^+ \pi^0 \gamma$
- ★  $\pi^+ \pi^0$  +accidental/splitted  $\gamma$

or

(After 3gamma trigger) ↓



classification by # of  $\gamma$ s

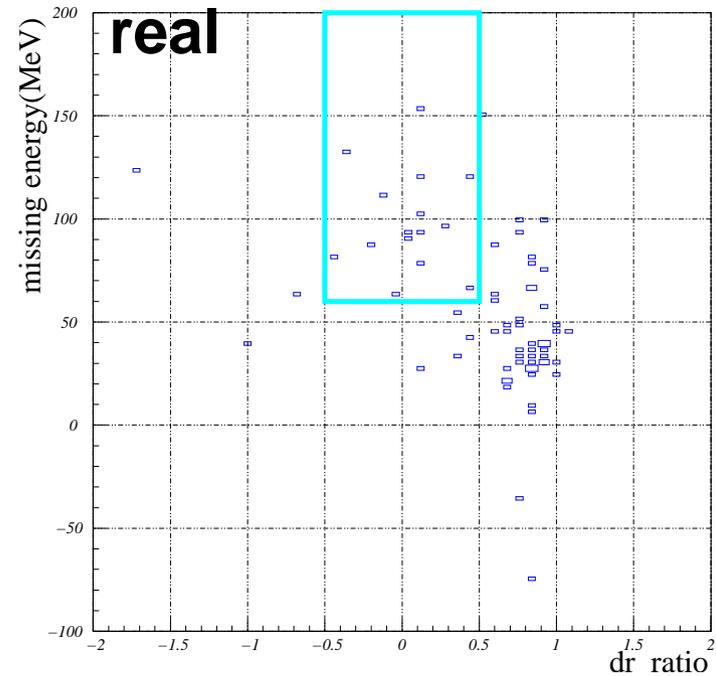
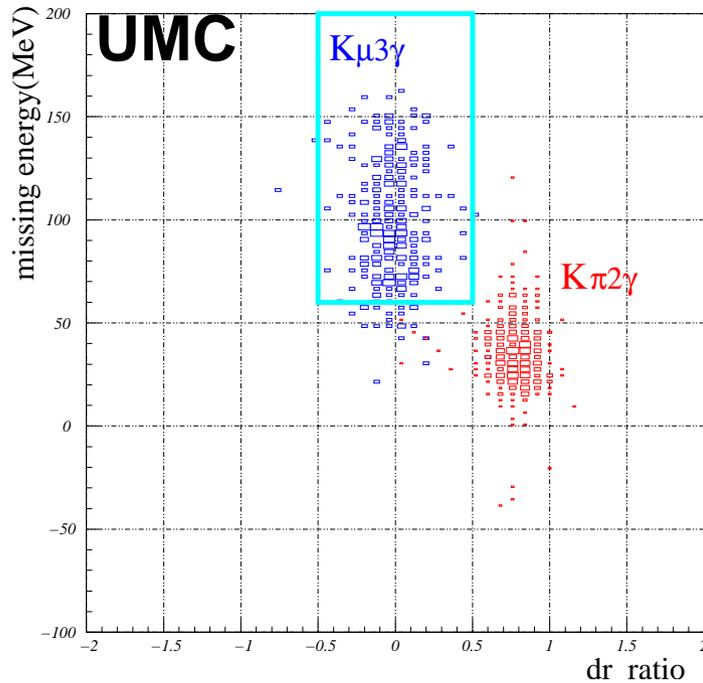
- ★  $4\gamma$  + 1 $\gamma$  is missed  
and/or charged track miss-ID
- ★  $3\gamma$  + charged track miss-ID
- ★  $2\gamma$  + fake  $\gamma$   
and/or charged track miss-ID

# *what was problem*

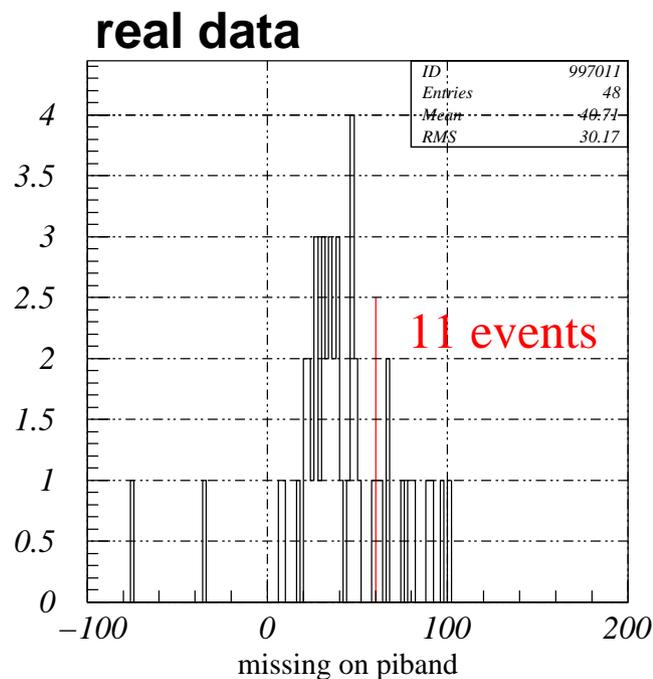
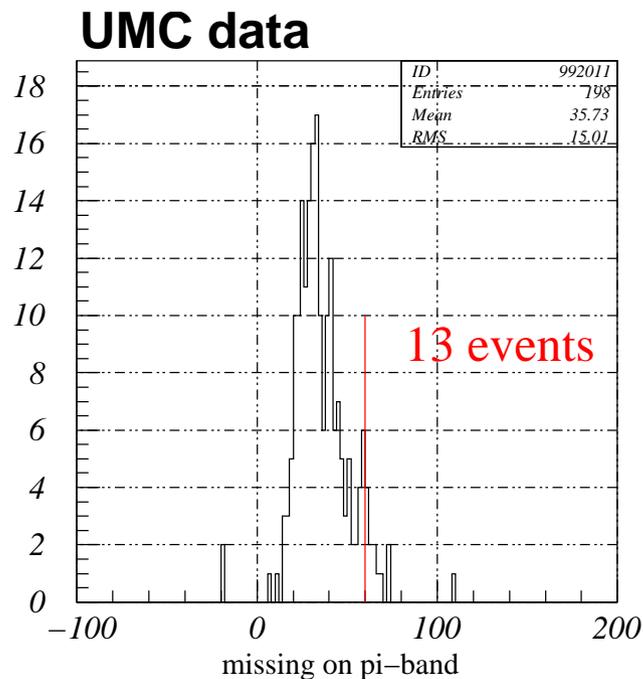
- ★ background estimation was still imperfect.
  - $K\pi 2\gamma$  background no concrete estimation.
- ★ EGCUT acceptance was so small

# $K_{\pi 2\gamma}$ background estimation

pure UMC-based estimation(using *corrected*  $F_s$ ):  $<0.194(90\%CL)$

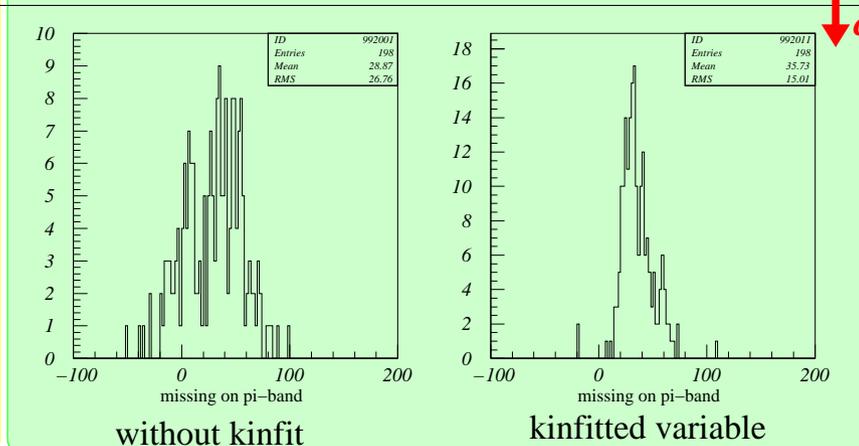
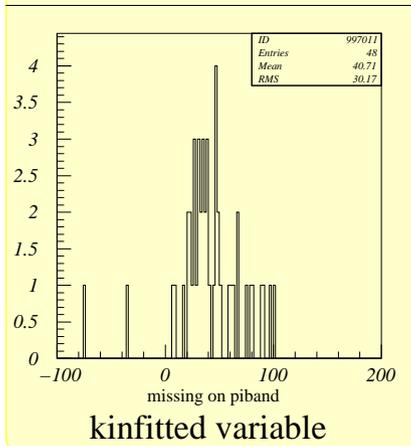
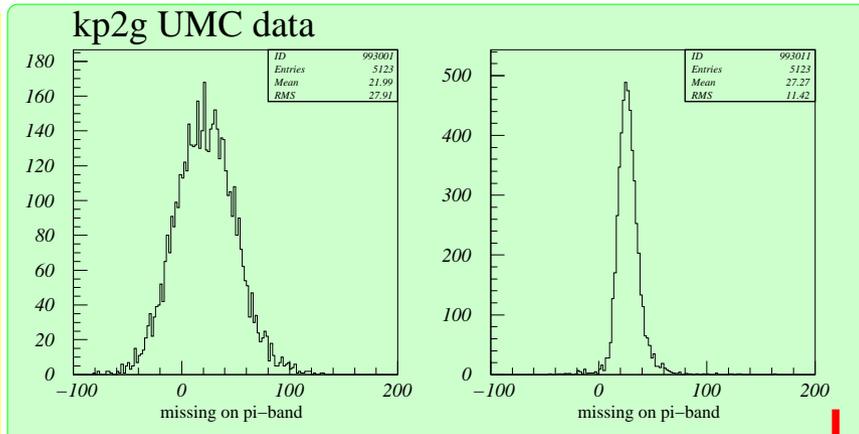
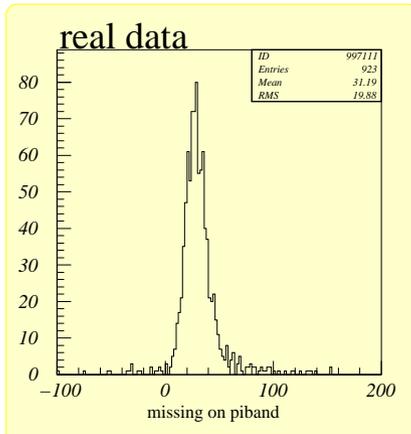


# missing energy tail of $K_{\pi 2\gamma}$ peak



UMC doesn't reproduce missing energy distribution of real data.

# kinfit tuning problems



Inconsistency might come from different kinfit tunings between UMC and real data.

# Kinfit tuning

smearing UMC data in order to use same kinematic fitting parameters.

smear variable set is same to TN370('95  $K_{\pi 2\gamma}$ )

$$\star \quad etot = etot + (0.332 * \sqrt{etot})\sigma$$

$$\star \quad ptot = ptot + \left(\frac{ptot}{100} \sqrt{3.567 - 0.1995 * \left(\frac{ptot}{100}\right)^2}\right)\sigma$$

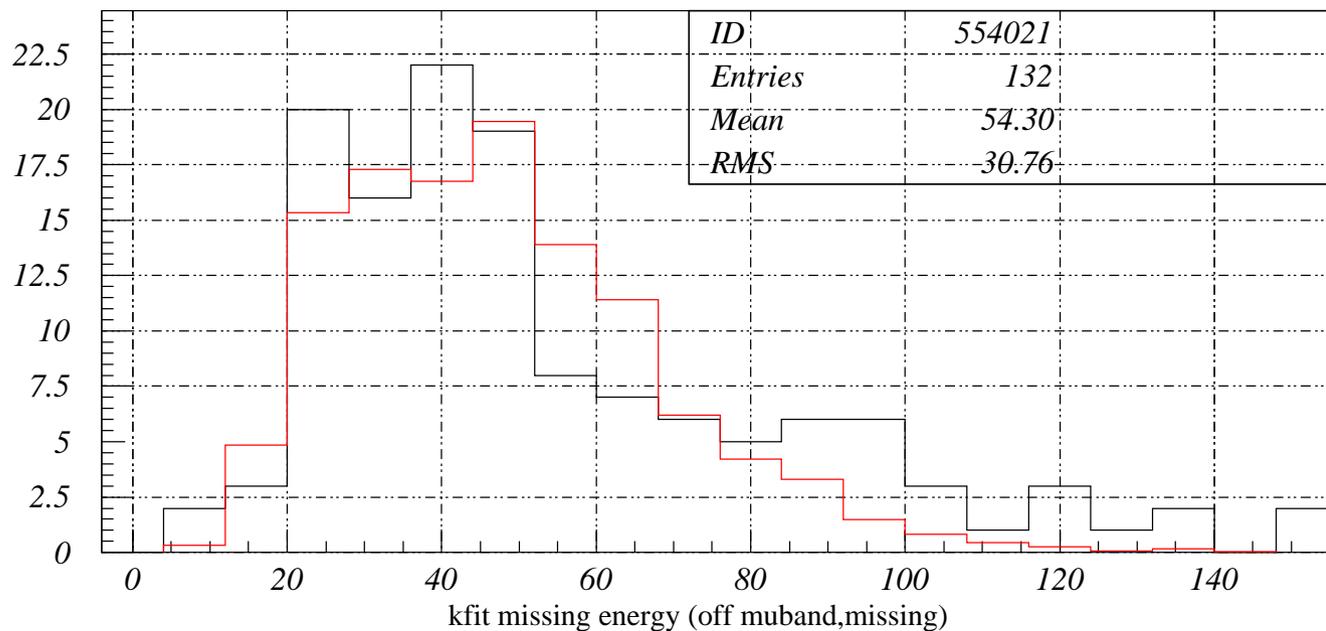
$$\star \quad E_{\gamma} = E_{\gamma} + 0.9800 \sqrt{E_{\gamma}}\sigma$$

$\star$  BV z offset  $\Leftarrow$  no smearing

,where  $\sigma$  means 'normal gaussian'

comlicated form is due to energy-dependent resolutuion

# Kinfit tuning result



Kp3 acceptance in this region(pion band) is enhanced.

absolute value of expected events in/out of s  
consistent with UMC expectation.

★  $K_{\mu 3\gamma}$  acceptance ← due to EGCUT

new problem”@

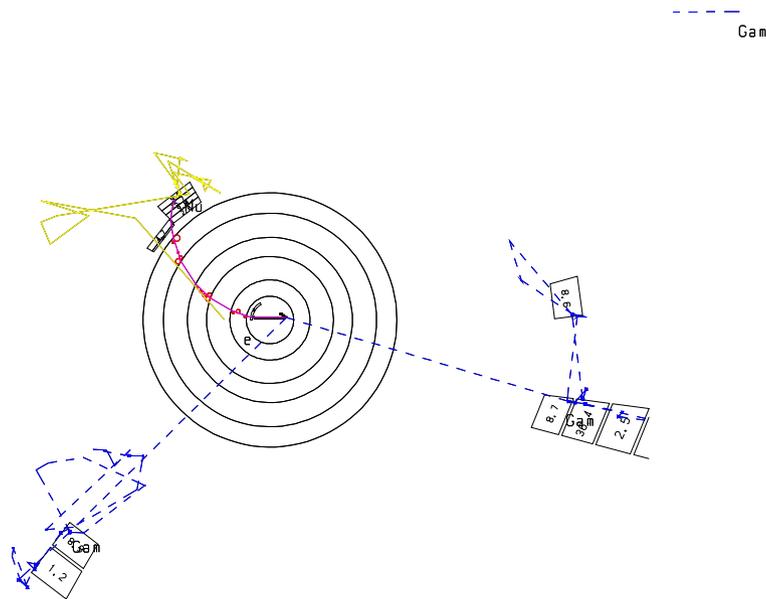
details will be studied. ← “lifetime of variable

# $K_{\mu 3}$ + splitted gamma

'splitted gamma' includes all non-accidental 3rd gamma

PNN(1) PNN(1)LO

SCALE 1:16.0



RUN 60023  
EVENT 615620

Bifurcation method is impossible. Using UMC, prove that this background is negligible.

# Background summary

From 1/3 sample study

sources	#events
$K_{\pi 3}$	$1.2 + < 4.1$
$K_{\mu 3} + Acc$	0.83
$K_{e3}/K_{e3\gamma}$	0.61
$K_{\pi 2\gamma}$	0.2
$K_{\mu 3} + \text{splitted } \gamma$	$< 1.63$
All Backgrounds	$2.8 + < 5.8$
real data(1/3)	14

#expected signal = 8.1 events(preliminary)

# *remaining problems*

---

new analysis codes are still inconsistent with old analysis codes  
,especially about overlapping photon cut etc.

# *Analysis schedule*

## Problems

- ★ analysis code consistency

## Full(or 2/3) sample study

- ★ background estimation consistency check
- ★ Physics result

# Summary

- ★ checked that smearing is important. But It needs more study.

**TODO**

- ★  $K_{\pi 2\gamma}$  background study.
- ★ Positive Evidence of signal  
good final plot(s)
- ★ Physics Results